Session: Nuclear knowledge retention (morning session of 12.05.05, chaired by Mrs. Dickman)

From Training towards Education in Safeguards[1]

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Abstract:

After the establishment of EURATOM and the International Atomic Energy Agency nuclear inspectors had to be trained. The Western safeguards methodology was soon recognized as an international standard and has been disseminated to Eastern countries such as the Newly Independent States. Nowadays a large variety of safeguards training courses are offered at the JRC sites in Ispra and Karlsruhe, at the US National laboratories, at the Russian Methodological Training Center in Obninsk, beside other nuclear organizations for expert courses.
However, for University students the safeguards terminology remains undefined. Academic education in nuclear engineering or physics covers typically the following three disciplines:

- *physics of atoms with neutronics and with nuclear instrumentation*
- *reactor technology, with thermal-hydraulics of nuclear systems (inclusive nuclear safety aspects)*
- *radiochemistry and nuclear materials,, inclusive the nuclear fuel cycle*

Safeguards aspects fall normally out of the scope in order to avoid any political discussion. With the media reporting extensively on suspect countries not respecting the agreements under the Non-Proliferation Treaty, students have pertinent questions on safeguarding of nuclear material and technology. Moreover each case of illicit trafficking of nuclear or radioactive material highlighted by the press reveals a concern on nuclear security.
The BNEN (Belgian Nuclear Higher Education Network), a national representative of the European Nuclear Higher Education Network (ENEN), recognized the need to address safeguards aspects under the format of an advanced course. A first course of 3 ECTS points (15 hr theory) has been organized for this BNEN year 2004-2005 with about 20 students. Moreover the BNEN Steering Committee accepted a first diplome thesis in this area, which initiated in October 2004.
The ESARDA "Course Modules" initiative can and should play a key role in teaching the safeguards terminology and methodology to docents at Universities by providing them the relevant information in a concise manner. It is the aim to establish for academic staff online (freely available after registration) 5 generic course modules:

- *introduction with an overview on the legislation and the national control systems*
- *principles and logic of safeguards with an overview on the fuel cycle and on the facilities with nuclear material of civil/military origin*
- *nuclear material accountancy and control methods (with Statistics, Physical Inventory Verification, Near Real Time Accountancy)*
- *accountancy and verification measurements (with Non-Destructive Assay, Destructive Analyses, Containment/Surveillance, Mass/Volume techniques)*
- *Integrated Safeguards (with Additional Protocol, Open Source Information Technology and Satellite Monitoring)*

Keywords: Training, Education, safeguards terminology

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1. Introduction

Since the 1950's the first nuclear power plants have been constructed and the nuclear technology was developing exponentially. Together with the nuclear industry and in direct support to both the utilities and the national inspectors, research centers have been investigating safety aspects with deterministic and probabilistic studies, supported by various experimental tests. During the seventies design basic accident studies were carried out, and formed a part of the safety licensing report. In the eighties also severe accident analyses have been carried out and lessons learned from some accidents (such as the Three Mile Island accident).

In the mean time, based on the Non-Proliferation Treaty and reinforced in the nineties with the Additional Protocol safeguards aspects have been addressed mainly by research institutions in support to the states, owner of the nuclear material and to the international inspectors (EURATOM and IAEA for the European Member States). Nowadays with the threat of terrorist attacks (such as on 11 September 2001) strengthening of the nuclear security should be one of the priorities of the international community.

Understanding of the nuclear safety and safeguards aspects is very useful to address the nuclear security in an efficient way. Maintenance of nuclear knowledge, also by the younger generation is therefore required. Not only communication to the public in general and training of professionals but also the basic education should be provided. Nowadays at European universities the nuclear discipline is rather limited because of the lacking popularity. Typically the following three disciplines are only addressed:

- physics of atoms with neutronics and with nuclear instrumentation
- reactor technology, with thermal-hydraulics of nuclear systems (inclusive nuclear safety aspects)
- radiochemistry and nuclear materials,, inclusive the nuclear fuel cycle

Although nuclear safety is recognized to be an important academic discipline, safeguards has not such statute. The more politicians discuss safeguards topics, the more these topics are avoided in an engineering education. As universities are already less and less teaching nuclear courses, especially university courses on the nuclear fuel cycle become rare and the introduction of a new safeguards course improbable.

Beside the emphasis on education in nuclear safety also the importance of education in nuclear safeguards has to be clearly indicated. The broad span of influence and control, direction and managing of nuclear materials, regulation and implementation of safeguards systems exhibited by a large number of professionals, nuclear facility managers, technical specialists, inspectors, diplomats, jurists, politicians, researchers and teachers, etc. has to be recognized. Moreover, Dickman [1] recently stated that, given the rapidly evolving world climate since the end of the cold war, education and training is needed for safeguards leaders and experts with a well-developed understanding of the broader political dimensions of current non-proliferation challenges.

The younger generation receives, via the various media, a lot of information about the risks of proliferation. One of the objectives of safeguards education is to provide them with the necessary technical background information, validated by the professionals and practitioners, enabling to make their own judgment on the various information sources.

2. Current safeguards community needs to engage younger generation

Traditionally the nuclear safeguards and non-proliferation programme of the past second half of the 20th century focussed on treaties, security controls at export borders, nuclear material accountancy and control systems with regulations, instrumentation, data analysis, remote verification. Nuclear research centres steadily developed enhancements and modernisations in the various fields of Non-Destructive and Destructive Analyses, Solution Monitoring techniques and Containment Sealing and Surveillance Systems. Less emphasis has been placed on recognition of the human element as a primary component of the research infrastructure and the key to successful and sustainable implementation of safeguards programmes.

Until nowadays, the safeguards community was limited to a relatively small and homogeneous society of informed specialists. This was simplifying the decisions making process and was enhancing the efficiency by more direct communication paths between its members. Now more and more people from various horizons have to deal with enlarged

subjects and increased importance of the fields.

New European Union borders even highlight the interest in homogeneous teaching material aiming at providing "European" approach to the various publics concerned. This EU harmonized material would also facilitate in medium term, a European approach to the nuclear Non Proliferation.

The replacement of a first wave of researchers and more generally technical people facing retirement becomes problematic because of lacking young graduates, engineers, physicists or technicians in the nuclear field. Moreover the teaching community itself decreases in number.

3. Embedding in existing educational networks

The OECD recommends to develop "educational networks among universities, industry and research institutes" [2].

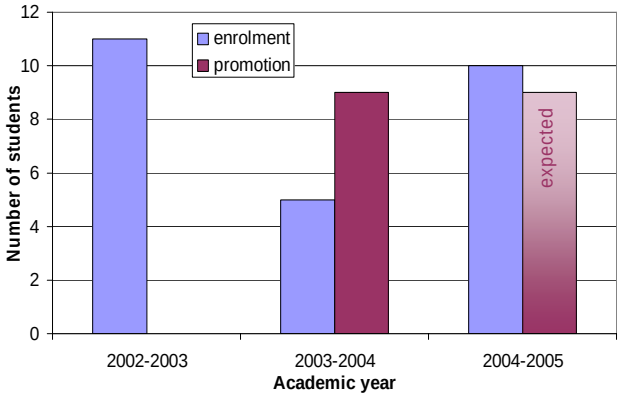

Fig. 1: BNEN students

The Commission supported and funded as EURATOM FP5 project the establishment of a roadmap for educational networks in the nuclear field. Such educational networks aim:

- guaranteeing nuclear knowledge and expertise through the preservation of higher nuclear engineering education
- optimally utilising the dwindling teaching capacity, scientific equipment and ageing research infrastructure through co-operation between universities and research centres

In 2001 a Belgian Nuclear Higher Education Network BNEN [3] was created with five Belgian universities (Vrije Universiteit Brussel, Katholieke Universiteit Leuven, Universiteit Gent, Université de Liège, Université Catholique de Louvain) and the Belgian Nuclear Research Centre SCKCEN as a joint effort to maintain and further develop a high quality programme of 60 ECTS (one full academic year [4]) for a "Master of Science degree in Nuclear Engineering". Fig. 1 gives and overview of the students for the master specialization in nuclear engineering that are enrolling respectively promoting. Under an FP6-action the outcome of this network will be evaluated by students, lecturers and a third neutral body in a final review report.

In parallel a similar network with a European dimension, the European Nuclear Higher Education ENEN [4], has been setup with a twenty-one universities and with the nuclear industry, regulators and research centers as stakeholders, mainly lead by INSTN/CEA. In the meantime this network has been growing towards the now so-called NEPTUNO network (Nuclear European Platform for Training and University Organisations) with 35 partners from Austria, Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Greece, Hungary, Italy, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Netherlands, United Kingdom. This European network is facing the second academic year and therefore no real statistical data can be shown. Up to now students enrolled and the first ENEN promotions are expected for the Summer 2005.

4. First experience with an academic course in Nuclear Safeguards

Upon request of the BNEN students a 3-days course on Nuclear Safeguards and Non Proliferation was organized at Ispra the first week of March 2005 as an Advanced Special Course with 3 ECTS in the BNEN programme. Eighteen students from various institutions (as shown in Fig. 2) attended the course. As safeguards topics: the legal basis, safeguards principles, accountancy auditing, destructive and non-destructive measurements, solution monitoring and containment surveillance have been addressed by seven lecturers from University Ghent, University Leuven, SCKCEN and from IPSC JRC Ispra and ITU JRC Karlsruhe during two full days. The third day was dedicated to the visit of laboratories and practical exercises. The schedule of the course

[4] ECTS: European Credit Transfer System: http://europa.eu.int/comm/education/socrates/ects.html

is given in Fig. 3. With the positive feedback, this course might be repeated yearly as part of the standard curriculum of the BNEN programme.

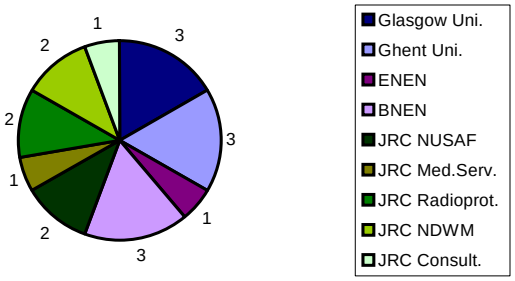

Fig. 2: Students of the first safeguards course

5. First dissemination of lecture notes

The lecture notes of the Ispra course, 1-3 March 2005, available to all participants, have been structured as follows:

- *introduction with an overview on the legislation and the national control systems: treaties & protocols, INFCIRC's*
- *principles and logic of safeguards with an overview on the fuel cycle and on enrichment, fuel fabrication and reprocessing facilities*
- *auditing of nuclear material accountancy (from statistical point of view, inclusive accuracy and frequency of Physical Inventory Verification, Near Real Time Accountancy)*
- *measurements for nuclear material accountancy and control (NMAC) with Solution Monitoring, Non-Destructive Assay (inclusive particle analyses), Destructive Analyses, Containment sealing and Surveillance Techniques)*
- *Integrated Safeguards (Open Source Information Technology and Satellite Monitoring as methods to verify compliance with the additional protocol) and illicit trafficking issues*

The organizers also archived the lecture notes on the MINERVA website[5] of the University of Ghent because students are nowadays used with on-line classroom and to download the course syllabus from the university internet with their userID and password. Exercises are becoming homework and the answers are commonly communicated by email. The interest in access via web and in computerised based training, such as expressed by the IAEA [5] is obvious.
Moreover to look up something, young people do no longer consult an encyclopedia in the library but are utilising web-search-motors such as google. Professors have to survey the quality of the information that students gather. Special emphasis was put on the ESARDA website[6] as information source at the end of the course.

Especially in the nuclear safeguards field the information is exuberant and it has been recognised that open sources contain a lot of information. In order to control the impact of the information spread over the web, it is needed to assess its value. Moreover to invest in well-trained future professionals, it is of high relevance to provide the students with that knowledge that they can judge, evaluate and interpret the large amount of information. So the availability of information "approved/ validated" by nuclear specialists will give a reference point to students in a fields were professors and specialists are becoming rare.

4. Perspective with future collaborations

Good course modules require different reviewers and being aware of similar initiatives in Europe (ESARDA), US (PNL, LANL etc.) and in the RF (IPPE etc.). It is of mutual interest to co-operate and to bring together the existing available information of high quality. Specialised institutes might have interest in detailed course modules, which could be added in a second step to an extended course. With the existing highly valuable and detailed information package e.g. on Non Destructive Assay by Los Alamos [6] or on Non-Proliferation Data by Monterey [7], or on specialised NMAC topics of the tripartite seminars in Obninsk [8] a collaboration should enable to establish a common nomenclature and symbol list and to include the links to their appropriate web sites.

An Internet Forum coupled with a safeguards training web site would help thesis and PhD students substantially. Also information on the practical modalities can be included by inserting links to Marie-Curie Fellowships, JRC

[5] https://minerva.Ugent.be/claroline/ssl/login.php

[6] http://www.jrc.cec.eu.int/esarda/

category 20 grants, INTAS trainee positions etc.

Bibliographical References

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[5] Bedke, M. International Safeguards Additional Protocol Implementation in the Department of Energy and National Nuclear Security Administration, http://www.ornl.gov/~websorks/cppr/y2001/misc/117786.pdf

[6] Horley, E. C. (LANL), eLearning and Certification for Non-Destructive Assay Operators and Inspectors, proc. 45th INMM (Orlando) July 2004 with CDROM on NDA Encyclopedia & Training Modules, No. LA-UR-03-5108, Oct. 2003

[7] Center for Nonproliferation Studies (Monterey Institute for International Studies), CDROM on Proliferation Databases including Nuclear Database, No. CNSDATA 4.0, May 2001

[8] Ryazanov, B. four Tripartite Seminars, resp. NMAC for fuel fabrication plants, NMAC for radiochemical plants, Nuclear material measurements and evaluation for physical inventory, Assessment of nuclear materials content and inventory in by-product streams http://www.rmtc.obninsk.ru/seminars/sseminar_eng.html, Obninsk, 1997, 1998, 2000, 2002

	Tuesday, 01.03.05	Wednesday, 02.03.05	Thursday, 03.03.05
8:45	Entrance permission	Entrance permission	Entrance permission
9:00	1. Overview on the treaties: NPT, AP, CTBT, START, ... (A. Poucet)	Solution monitoring and Near Real Time Accountancy (G. Maenhout)	Visit to the PERLA laboratory (P. Peerani)
10:15	coffee break	coffee break	coffee break
10:30	Nuclear fuel cycle (G. Maenhout)	Destructive Analysis: Measurement principles and uncertainty (K. Mayer)	Visit to the TAME laboratory (G. Maenhout)
11:45	Principles and logic of nuclear safeguards (K. van der Meer)	Environmental sampling, particle analysis, nuclear forensics (K. Mayer)	Satellite Monitoring (M. Thornton)
13:00	Lunch	Lunch	Lunch
14:00	Overview of Safeguards Techniques (K. van der Meer)	Non destructive analysis: gamma-spectrometry (P. Peerani)	Visit to the C/S laboratory (V. Sequeira)
15:15	coffee break	coffee break	coffee break
15:30	What is good accountancy from statistical point of view ? (M. Franklin)	Non-Destructive Analysis: neutron-counting (P. Peerani)	Presentation of ESARDA (L. Bril)
16:45	Auditing an accountancy (M. Franklin)	Surveillance and Remote Monitoring, Design Information Verification (J. Goncalves)	Conclusions and Wrap-up
18:00	Closure	Closure	Closure

Fig. 3: Schedule of the first ENEN safeguards course, Ispra, 1-3 March 2005